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ORGANIC MAINTENANCE PERFORMANCE MEASUREMENT: A NEW APPROACH

THESIS

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THESIS

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Preface

We created this thesis to address dynamic management challenges in the defense organic maintenance environment, brought about by diminishing DOD resources, and expanding organic maintenance roles. Our thesis discusses three topics. In the first topic, we identify current performance measurement tools available to organic maintenance management. Our second topic is a description of the current Earned Value (EV) performance measurement concept and its application to organic maintenance environments. Our third topic identifies organizational and cultural changes taking place in organic maintenance that will aid management control and EV implementation.

We thank our advisor, Richard Antolini, for his expert advice, patience, enthusiasm, and many hours of counsel, without which we could not have accomplished this quality document. We also extend gratitude to our co-advisor, David Christensen, for introducing us to Professor Antolini, and for helping us improve the readability of this thesis. We express appreciation to the helpful personnel from organizations we researched, whose inputs were our data. We express the greatest thanks to our wives, Linda, and Theresa, for their understanding, love, support, and patience throughout this research effort.

John S. Nehr William G. Queener

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Abstract

The growing role of Air Force Air Logistics Centers (ALC) in complex, multi-year developmental programs increases the need for effective cost and schedule performance measurement. In order to effectively manage these activities, timely and accurate cost and schedule information must be collected and compared with an established baseline. The ALCs need a new management technique that facilitates this type of performance measurement.

A proven approach to cost and schedule performance measurement in weapon system acquisitions is EV. This approach, required of contractors who are subject to the Cost/Schedule Control Systems Criteria (C/SCSC), allows the program manager to obtain cost and schedule variances at one month intervals during program execution. These variances corroborate known program problems, or give a first indication of potential problems within a program.

This thesis describes what performance measurements are currently in use and how the EV concept can be applied to organic maintenance programs. This document also relates management challenges to the implementation of an EV measurement system at organic maintenance facilities.

ORGANIC MAINTENANCE PERFORMANCE MEASUREMENT: A NEW APPROACH

I. Introduction

The Department of Defense (DOD) budget, in terms of purchasing power, has diminished markedly over the past decade. Both the decline and breakup of the Soviet Union and increased concern over the Federal deficit have driven Congress to reduce defense spending. Because of this budget reduction trend, the Air Force is purchasing fewer weapon systems. Consequently, the Air Force is beginning to concentrate more of its resources on maintaining existing war fighting capability and upgrading current weapon systems.

This approach is leading to changes in the allocation of DOD budget dollars. For example, Air Force organic maintenance funding is projected to increase in the President's fiscal year (FY) 95 budget (2:4), and is expected to increase in future years. In fact, the budget focus on organic maintenance is not a unique Air Force situation. DOD depot maintenance funding is projected to rise 20% in FY 95 (2:3). This boost is intended to meet increased demand for future modifications and repairs to be performed through internal DOD organic maintenance and by industry. This trend toward continuous upgrading can be expected to continue into the future.

Within the Air Force, the organization responsible for designing, developing, testing, fielding, upgrading, and repairing of weapon systems is Air Force Materiel Command (AFMC), headquartered at Wright Patterson Air Force Base (WPAFB), Ohio. AFMC was created in 1992 by combining Air Force

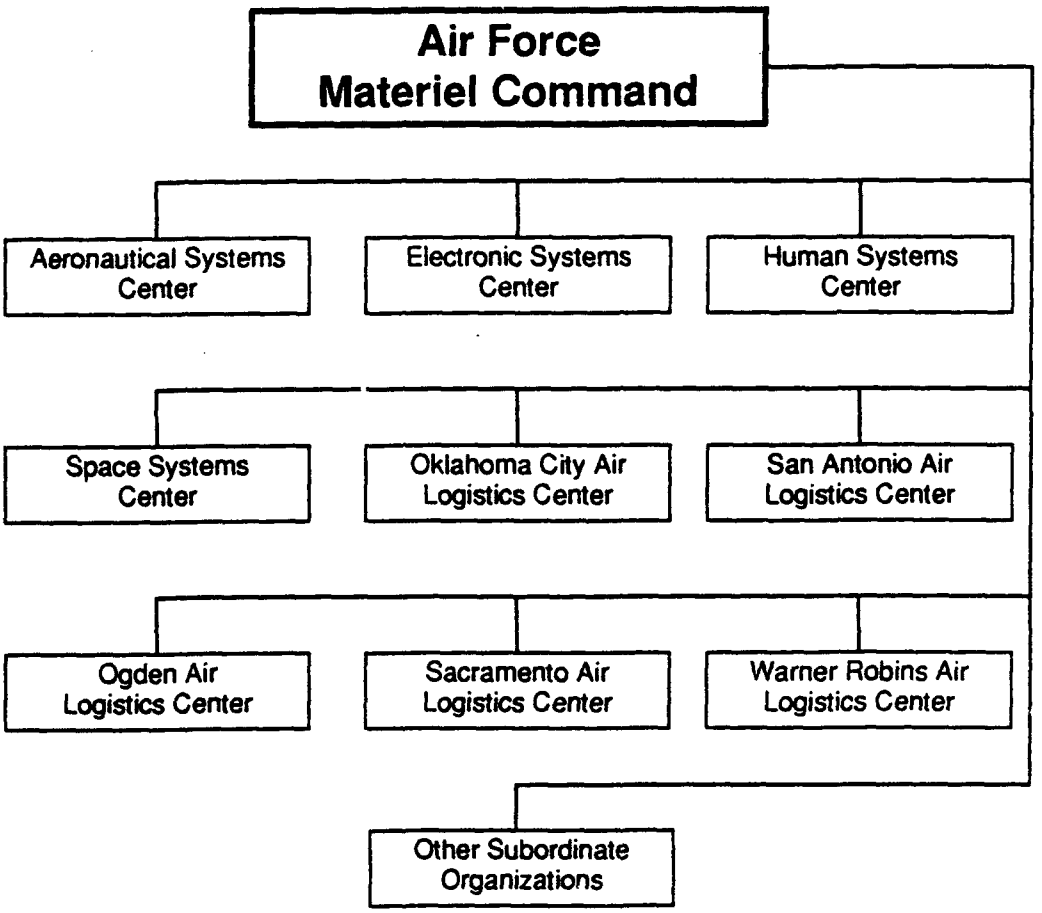


Figure 1. Air Force Materiel Command Organizational Structure

Systems Command (AFSC) and Air Force Logistics Command (AFLC), which were responsible for acquisition and logistics support, respectively. As seen in Figure 1, AFMC oversees acquisition centers and ALCs. Acquisition centers, such as the Aeronautical Systems Center (ASC), are primarily responsible for designing, developing, testing, and fielding of weapon systems. ALCs, such as Warner Robins Air Logistics Center (WR-ALC), are primarily responsible for depot maintenance, which is repairing, maintaining, and upgrading fielded weapon systems.

Depot maintenance can be divided in two categories. In the first category, organic maintenance, the depots are responsible for the management and performance of maintenance activities. In the second category, contract maintenance, the contractor is responsible for the management and performance of maintenance activities. The focus of this thesis is performance measurement within the organic maintenance environment.

As shown in Figure 2, organic maintenance includes three major types of efforts. The first, routine maintenance, is the continuous support of fielded systems, including hardware repair and replacement, and software maintenance. Hardware repair and replacement are accomplished at the system or component level, with either parts fabricated in-house or purchased. Software maintenance involves the upgrade of fielded software due to changing operational requirements.

The second type of organic maintenance, reliability and maintainability upgrades, is the improvement of selected fielded hardware and software components or systems to make them more supportable and mission capable.

The third effort, labeled here as acquisition activities, was previously limited to the acquisition centers. "Acquisition activities" includes the

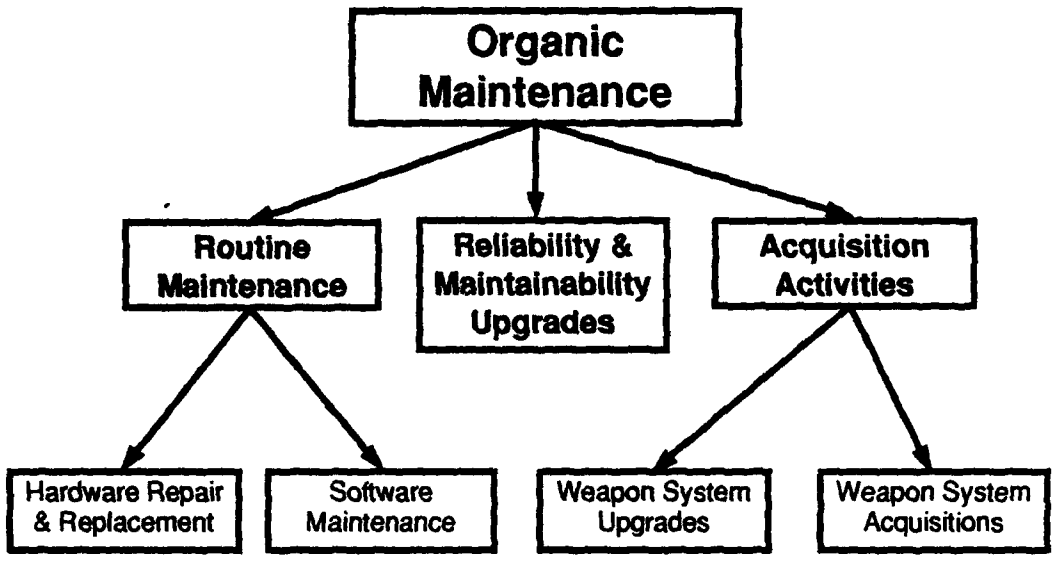


Figure 2. Types of Activities Found at Organic Maintenance Facilities

performance of upgrades to existing weapon systems, and potentially the acquisition of weapon systems and components

ALCs performing acquisition activities will require the implementation of innovative management concepts. The acquisition activities tend to be complex and of longer duration than the other two categories of organic maintenance defined above. Therefore, existing management control tools must be evaluated and modified as necessary to meet the new challenges. In order to manage these activities, cost and schedule information must be collected and compared with an established baseline. Management techniques and systems facilitating this type of performance measurement will be required.

Earned Value

EV is a proven approach to major weapon system cost and schedule performance measurement. Critical in the EV concept is determining the value

amount of work performed at any point in time, as expressed in terms of the budgeted dollars for the same work (15:20-21). In an EV system, task performance is measured at the lowest level of a contractor's detailed work plan (14:29). These measured values of the work performed are summed to obtain the program-level EV (14:29). By using the EV approach, the manager is provided three measurements: the budget for the work, the value of the work performed, and the cost of the work performed. The budget and the cost of the work performed are compared with the value of the work performed to calculate variances. To ensure traceability and to aid problem identification, the variances are calculated at lower levels, as well as at the program level.

EV is the key concept to the C/SCSC. Through C/SCSC, the program manager obtains variances at defined intervals, during program execution (10:11-B-2 - 3). These variances may corroborate known program problems, or give a first indication of potential problems within a program. Cost variances (CV) indicate if a program is spending more or less than the value of the work performed to date. Schedule variances (SV) indicate if the work is being completed when planned. If variances are beyond a threshold, the contractor program manager must investigate the cause of the variance and take corrective action as necessary (10:11-B-1-3).

Management Control

When integrated with technical performance management, EV facilitates effective management control. The EV cost and schedule performance indicators show current and cumulative trends, identify existing or potential problems, and aid in estimating total cost at program completion. Thus, the EV approach can be used to accurately track program progress. This contrasts with

traditional methods of tracking which focus on spend rates or other indicators such as manpower availability.

Competition

The change in depot focus toward acquisition activities is not the only reason better cost and schedule performance data is needed. The introduction by DOD of Depot Maintenance Competition (DMC) also has heightened the awareness of the need for better data. Begun on a trial basis in 1991, these competitions were classified as either Public-Private (government-industry) or Public-Public (government-government). The first type was a competition between organic maintenance and private industry, while the latter was a competition between two or more DOD depots. In both competitions, organic maintenance bidders were required to develop proposals and to identify methods of tracking performance comparable to those methods expected of contractors.

Public-Private competition stirred much controversy. Private industry exerted pressure on the US government to allocate to the private sector some of the 60% of the non-acquisition organic maintenance work currently reserved by law for the depots. Industry advocates have argued that open competition between public and private entities unfairly favors the public sector. AFMC, however, has defended Public-Private competition, stating that significant savings have been realized through competition between the Air Force and private contractors (23:A6).

In addition to saving money, the organic maintenance competition programs increased awareness of the need for better cost and schedule performance measurements, such as those offered by EV. However, the DOD is

currently recommending to Congress the cancellation of Public-Private competition (11:462). It supports the creation of a DOD-wide core workload. Core workload is defined as the maintenance work that must be performed by organic maintenance at the Service depots. Industry would compete for non-core workload. Interservicing procedures will be used in lieu of Public-Public competition for core workload. The DOD is currently defining what maintenance activities will comprise core workload. (11:462)

Research Questions

Contractors implement the EV management concept to meet the requirements of the C/SCSC. EV concepts appear appropriate for organic maintenance programs. To this end, the authors' research focused on performance measurements currently in use or planned for implementation within the organic maintenance environment. Special emphasis was given to the potential implementation of the EV approach through interfacing with or supplementing existing performance management tracking systems. Specifically, this thesis investigated:

1. The existing procedures, processes, and systems used to acquire cost and schedule performance data within organic maintenance.

2. The cost and schedule performance measurements used for organic maintenance by the Air Force at higher management levels.

3. When existing performance measurements were provided to management and if these measurements were effective for managing programs within the organic maintenance environment.

4. Whether EV concepts could be implemented by organic maintenance organizations and how could its implementation aid effective program execution.

Scope of the Research

The research documented by this thesis was conducted for two reasons: the changing of organic maintenance workload toward acquisition activities, and the increased emphasis on performance data due to Public-Public and Public-Private competition. To focus the investigation, the researchers developed the above research questions. To answer these questions, the researchers: conducted an in-depth literature review of EV and C/SCSC guidance, interviewed key organic maintenance managers and functional personnel, and analyzed organic maintenance management procedures and systems.

Due to resource constraints, the researchers did not validate the findings through on-site evaluations of organic maintenance management systems. The researchers' investigation was limited to analyzing documentation describing the F-111 Stores Management System (SMS) Upgrade program at the Sacramento ALC (SM-ALC).

Methodology

Applying EV to the organic maintenance environment is a new concept. In fact, there is no documented example of a DOD program fully implementing EV. The researchers investigated current and proposed AFMC guidance on performance tracking by meeting with logistics and financial management personnel. The researchers also interviewed managers of current and proposed

organic maintenance cost and schedule tracking systems. Because the investigation encompassed such a broad subject area, an exploratory, high-level, research approach was considered appropriate for this thesis.

Thesis Structure

This thesis is divided into five chapters, the first of which is this Introduction. Chapter Two, Literature Review, is a review of EV concepts, as applied to industry. The C/SCSC are discussed and an introduction to EV is presented. Chapter Three, Methodology, describes the research approach, and documents the scope of the thesis effort.

Chapter Four, Analysis, presents the information collected through interviews and associated organic maintenance related documentation. This chapter describes current cost and schedule performance measurement direction, discussing the F-111 SMS program as an example, reviews the proposed Depot Maintenance Management Information System (DMMIS), and identifies changes to organic maintenance organizational structures.

Chapter Five, Conclusions, answers the research questions, and comments on the generalization of the results. Relevant observations concerning the implementation of EV concepts and suggestions for future research are then provided.

II. Literature Review

Overview

Performance measurements may be obtained by applying EV concepts to organic maintenance programs. EV trend and performance indicators could be important tools that would aid the effective controlling and reporting of program cost and schedule. The DOD EV concept has evolved over the past three decades and a considerable body of literature exists describing this management concept. This literature review discusses the history and basic requirements of the C/SCSC and the concept of EV.

C/SCSC Background

The EV concept has been a keystone of the DOD major system acquisition for some time and is used by numerous Federal Civilian Agencies, such as Department of Energy, Department of Commerce, and Federal Aviation Agency, among others. The DOD, the first government agency to implement EV, mandated C/SCSC on contracts on December 22, 1967. The DOD detailed this requirement in DOD Instruction 7000.2, Performance Measurement for Selected Acquisition (12:25). This document contained the 35 criteria which contractor management systems were required to meet. The C/SCSC require the contractor to "define the work required to meet contract objectives, assign the work to specifically identified organizational elements, establish internal

schedules and budgets, and periodically compare cost and schedule performance indicators against planned budgets and schedules" (29:211). The 35 criteria have remained basically unchanged since their introduction (4:10). DOD Instruction 7000.2 was superseded by DOD Instruction 5000.2, February 23, 1991. These criteria are applied to Research, Development, Test and Evaluation (RDT&E) contracts exceeding $60 million, and procurement contracts exceeding $250 million, in constant 1990 dollars (10:11-B-2).

Acceptance of the Criteria

When the C/SCSC were first published, they were generally viewed as "a very positive step toward helping solve management problems" (17:D.11.2). In fact, the consensus is that "C/SCSC requirements have been overwhelmingly acknowledged by both government and industry managers as representing good management principles" (21:E.2.1). In 1982, fifteen years after C/SCSC was first mandated, the DOD contracted with the management consulting firm of Arthur D. Little Company (ADL) to independently review C/SCSC. The stated purpose of the study was to:

> Determine the degree of acceptance and use of the C/SCSC by defense contractors and government program managers; identify problems and issues, the resolution of which could lead to improvements in the C/SCSC and contract performance measurement reporting requirements: and recommend policy changes that will lead to these improvements and could be implemented by the Assistant Secretary of Defense (Comptroller). (6:1-1)

The findings contained in the report were based on surveys and interviews with DOD and contractor personnel (6:1-1). The report contains seven specific findings (6:1-2 - 3) and ten specific recommendations for improving the implementation of C/SCSC (6:IV-2). The first finding was that there was "general endorsement of the criteria concept, both from government and private industry" and that both groups "considered C/SCSC to be effective and to outweigh the costs involved" (6:1-2). Thus, one may conclude that the C/SCSC has general acceptance for use on DOD programs.

The C/SCS Criteria

When C/SCSC is implemented on a contract, the contractor must demonstrate that the contractor's management system complies with 35 criteria. The criteria are grouped into five categories: Organization, Planning and Budgeting, Accounting, Analysis, and Revisions and Access to Data (3:2-3 - 2-4). These five categories are presented below.

Organization. These organization criteria ensure that the contractor will "define all authorized work and related resources to meet the requirements of the contract, using the framework of the CWBS [Contract Work Breakdown Structure]" (3:2-3). The contractor must also integrate the CWBS with the contractor's functional organization and "provide for the integration of the contractor's planning, scheduling, budgeting, work authorization and cost accumulation systems with each other, the CWBS, and the organization

structure" (3:2-3). Furthermore, the contractor must demonstrate the ability to comply with all the aforementioned requirements (22:50).

Planning and Budgeting. These criteria do not specify a particular planning or scheduling technique, but mandate that the chosen approach have certain capabilities. The contractor must "schedule the authorized work in a manner that describes the sequence of work and identifies the significant task interdependencies required" (3:2-3). To fulfill the budgeting requirements, the contractor must also "establish and maintain a time-phased budget baseline at the cost account level against which contract performance can be measured" (3:2-3).

Accounting. The third category applies to contractor recording of direct and indirect costs incurred which apply to the contractor effort (3:3-13). "Such costs must be directly summarized from the level at which they are applied to the contract through both the WBS and functional organization structures according to procedures acceptable to DCAA (3:3-13)."

Analysis. The objective of these criteria is to conduct performance measurement through the calculation of variances and determining the causes for deviations through variance analysis. The contractor determines the variances by comparing both actual costs and the cost of the work scheduled with the budgeted cost of the work performed. The Variance at Completion (VAC) is determined by comparing the Budget at Completion (BAC) with the

Estimate at Completion (EAC). BAC, EAC and other EV terms are defined in Appendix A.

Analysis criteria require the calculation of various quantities used for comparison at the cost account and higher level. Variance Analysis requires the availability of five quantities: Budgeted Cost for Work Scheduled (BCWS), Actual Cost of Work Performed (ACWP), Budgeted Cost for Work Performed (BCWP), Budget at Completion (BAC), and Estimate at Completion (EAC).

Revisions and Access of Data. The fifth category of the criteria "pertains to revisions to planning which are necessitated either by contractual change or by internal conditions which require replanning within the scope of the contract. It also deals with maintaining the validity of the performance measurement baseline" (3:2-4).

Variance Calculations. To conduct the required analysis, three primary indicators must be computed. These indicators, BCWS, BCWP, and ACWP are calculated at the cost account level, which is the lowest management control point within the contractor's organizational structure. Higher level comparisons determine summary contractor performance for each portion of the contract. At the cost account level, the contractor subtracts BCWS from BCWP to obtain the Schedule Variance (SV), and subtracts ACWP from BCWP to obtain the Cost Variance (CV) (3:2.4).

SV indicates work completion status, behind or ahead of the planned schedule. However, one can not assume that if work is behind schedule, the

program is behind schedule. The work may have been scheduled earlier than required, or may not be critical to the success of the program. The EV measure of SV provides a good method for measuring to-date schedule attainment, but it does not measure the relative criticality of uncompleted tasks (7:60). Additional analysis must ascertain the true impact of the schedule variance.

CV shows whether the cost of the work is being performed at the planned budget. The CV for the entire contract is the summation of the CVs of the cost accounts. The variance is a relative measure of whether contract performance can be obtained within the budgeted cost envelope. The method chosen for estimating the BCWP, or EV, is critical to the correct calculation of CV and SV.

Calculation of CV and SV permits the contractor to assess cost and schedule performance separately. "The traditional method of reporting cost variances [in private industry] has been a comparison of budget with the actual expenditure. It never takes into account the value or worth of the accomplished work" (20:A.1.4). Thus, the traditional approach would show a favorable CV as long as the program was spending its budget at the anticipated rate. The EV approach, however, would give favorable CVs only if the actual cost of the work performed is lower than the BCWP. The EV CV, therefore, provides the manager with a much improved measurement of cost performance.

Cost Accounts

BCWP represents EV, and is measured at the cost account level for direct costs. The DOD defines a cost account as "a management control point at which actual costs may be accumulated and compared to the budgeted cost of the work performed. [A cost account is] a control, because it represents the work assigned to one responsible organizational element on one contract work breakdown structure element" (10:11-B-2-2). There are three types of cost accounts, as described below: Level of Effort (LOE), Apportioned, and Measured (12:119).

Level of Effort. The DOD defines a level of effort as an "effort of a general or supportive nature that does not produce definite end products" (10:11-B-2-2). Fleming indicates that "LOE activities are those which are necessary to a program, but which are more time oriented than task-related" (12:120). Program management, security, and contract administration are frequently considered as LOE activities . In this type of cost account, the BCWP always matches the BCWS, thus creating a zero SV. A CV, however, could arise if the cost actuals (ACWP) are not equal to the budgeted costs (BCWP).

Apportioned Effort. Apportioned effort is effort that is not readily divisible below the cost account level, but is related proportionately to measured effort (10:11-B-2-1). One example of an apportioned effort would be factory inspection, which is budgeted as a fixed percentage, such as eight percent, of factory labor. The factory labor, in this example, would be the reference base for

factory inspection. The assumption is that the requirement for the apportioned effort is directly proportional to the reference base. The EV, or BCWP, will be set at the fixed percentage of the BCWP of the reference base. In the example, the factory inspection will be credited eight dollars for each 100 dollars of BCWP earned by the factory labor. Thus, the SV of the apportioned effort always reflects the status of the effort's reference base. The CV is the difference between the ACWP for the apportioned effort and the derived BCWP. Thus, an apportioned effort may have a negative CV, even when the reference base has a positive CV.

Measured. The intent of the C/SCSC guidance is to minimize the use of LOE and apportioned effort cost accounts. Measured effort consists of discrete tasks which have a specific end product or end result. The majority of the work is expected to be accomplished in measured cost accounts. Therefore, most of the focus of EV discussions relate to this type of cost account. The EV for unstarted work within a measured cost account is zero. The EV for completed work in a measured cost account is equal to the budgeted cost of that work. The true challenge is estimating the EV for work started, or "opened," but not completed work. The DOD Joint Implementation Guide states: "The major difficulty encountered in the determination of BCWP is the evaluation of in-process work" (3:2-4). EV is a measure of the work that has actually been accomplished.

Earned Value Calculation Methods

The criteria do not mandate specific methods for calculating the EV, but do require that the same method used to measure the BCWS is used to develop the BCWP. This consistency allows for meaningful comparisons of the budget with the actual results.

There are a number of methods for determining BCWP, the following six methods have gained general acceptance: 50/50, 0/100, Milestone, Percent Complete, Equivalent Units and Earned Standards. Of these methods, the Milestone and Percent Complete are the two most utilized by contractors with approved C/SCSC systems. These methods are defined in Appendix B. (12:125)

Implications for Air Force Organic Maintenance

The general opinion of the literature reviewed was that the EV approach provides useful cost and schedule information to management. Additionally, the EV is used commercially on many projects, large and small (1:J.2.5) (15:23).

Within DOD, the potential exists for application of the EV concept. For example, the Sacramento Army Depot (SAAD) planned to implement the EV concept on the Firefinder Radar Project (4:56). However, due to the closing of SAAD, the program transferred to Tobyhanna Army Depot (TOAD), and the EV measurement attempt was abandoned. The Army did learn, however, that

proper implementation would require strong headquarters leadership, new and modified software tools, and trained personnel (4:66-67). The Navy is also investigating the implementation of EV concept in naval organic maintenance environments.

By applying the EV concept, the Air Force organic maintenance organizations can apply effective management control to acquisition activities and selected routine maintenance programs.

III. Methodology

The concept of applying performance measurement techniques used by DOD on major systems acquisition to organic maintenance environments was approached using exploratory research techniques. This research style is most appropriate because little is known of the applicability of the EV approach to Air Force organic maintenance programs. As previously stated, there is no known example of an organic maintenance program fully implementing C/SCSC. There are, however, a growing number of potential efforts requiring cost and schedule tracking. Data very similar to that collected under the EV concept will be needed to aid in the management of these programs.

Approach

The C/SCSC literature review identified research information sources including government reports, instructions, directives, textbooks, periodicals, and a thesis. From these materials, the researchers compiled a high-level summary describing the EV concept and its implementation. The Literature Review describes how EV aides management control of projects. From this review, the researchers determined that the EV concept could aid organic maintenance management control.

To discover which performance measurements were currently used and which were planned, the researchers interviewed key personnel at HQ Air Force Material Command (AFMC) and reviewed current HQ AFMC guidance. The

information collection focus centered on current and future performance measurement methods and systems.

The open dialogue approach yielded information that would be otherwise obscured. The interviewed personnel provided the high level policy perspective on cost and schedule performance measurements, as well as copies of current and proposed guidance and direction to be implemented on ALC programs.

Additional information was obtained from an academic analysis of the cost and work measurement aspects of the F-111 SMS Upgrade program (5:1). Although this upgrade was not completed, SM-ALC's attempt to utilize the EV concept on this effort is a good example of Air Force EV implementation.

This thesis evaluates the F-111 SMS Upgrade program as a case study and compares the program's proposed performance measurement system with the requirements for an EV measurement system. The case study yielded results that may be generalized and applied to other organic maintenance programs attempting to implement EV measurement.

To answer the thesis questions, the researchers collected information on the current ALC method for collecting cost and schedule performance measurements, a future performance measurement system planned for organic maintenance environments, and the organizational structure supporting the collection of useful, timely, and valid cost and schedule performance measurement.

IV. Analysis

Overview

EV can be an important tool for the ALCs to monitor and control program cost and schedule. This chapter discusses three major topics related to the EV concept. First, a discussion of the ALCs' current method for collecting cost and schedule performance measurements will be presented. The second topic is a description of DMMIS, which is a planned organic maintenance performance measurement system supported by AFMC. The third topic discusses the organizational structure supporting the collection of data. The concept of establishing a Project Administration Officer (PAO) position at each of the ALCs represents an example of potential organization changes.

Current Cost and Schedule Performance Measurement

Current documents, reports and systems are described in the following four sections. To discuss the current measurements that are being produced on organic maintenance programs, one must first review the basic tasking documents and cost data collection processes. Therefore, the first section describes the Work Assignment Document (WAD), and basic cost data collection processes. The second section discusses a currently used cost and schedule tracking report, the Depot Maintenance Performance Tracking Report (DMPTR). The third section describes the Programmed Depot Maintenance

Scheduling System (PDMSS), a scheduling system in use at Air Force organic maintenance organizations, (28). The fourth section details an attempt to perform EV measurement on the F-111 SMS Upgrade Program at SM-ALC.

Workload Assignment Document. The Workload Assignment Document (WAD) is the basic Air Force agreement document between the buyer (customer) and the seller. The buyer is often a major using command, and the seller is typically the ALC. The WAD, ranging from several to several dozen pages, defines the terms and conditions, such as the fixed cost and schedule, for the work to be done (9). The WAD terms are determined through negotiations between the buyer and the seller.

An example of a WAD would be an Air Combat Command (ACC) request for Ogden ALC (OO-ALC), to upgrade the F-16 landing gear at a negotiated cost and schedule. Another example of a WAD could be a flight computer upgrade. The F-111 SMS Upgrade Program was a weapon system upgrade acquisition activity executed through a WAD. An example of a WAD executed on this program is provided in Appendix C.

After the customer and the depot agree to the scope of effort to be accomplished within a period of time for a specific cost, the customer funds that work through a Project Order (PO). The PO provides the funding required and identifies the units affected. When the PO is received, the budget and schedule information is loaded into the G004L Job Order Production Master System. This

system is one of over twenty "legacy" systems, currently operating at Air Force organic maintenance facilities, used to collect and process cost and budget data.

When the PO provides the funding, work begins, and costs are collected as the units are produced. The primary computer system responsible for the collecting actual costs is the G072A Depot Maintenance Production Cost System. The overhead rates are included in the costs, and the customer is then billed through the G004B Project Order Control System. Both the G072A and the G004B are legacy computer systems. The customer is billed at the agreed upon WAD price as units are completed. (9)

Standard billing rates are used in the WAD. This is because DOD depots use a two year stabilized rate system to support the customer's funding request cycle. This funding system requires the depot to submit one-year rate quotes for future years. The rate quote is provided up to two years before the work begins.

Depot Maintenance Performance Tracking Report. The procedures described above result in cost data collection and actual cost realization primarily after a unit is produced. Therefore, the actual cost data are not compared with the budgeted cost data in any systematic process during program execution.

To facilitate collecting cost and schedule performance information, AFMC has developed the DMPTR. This report, shown in Figures 3 and 4, consists of a schedule and cost report and requires an assimilation of existing legacy system information. The DMPTR provides cost and schedule information primarily from

existing management systems. This thesis discusses data contained in the DMPTR. Although terms such as "earned value" are absent from the DMPTR, it contains data similar to that found in an EV system.

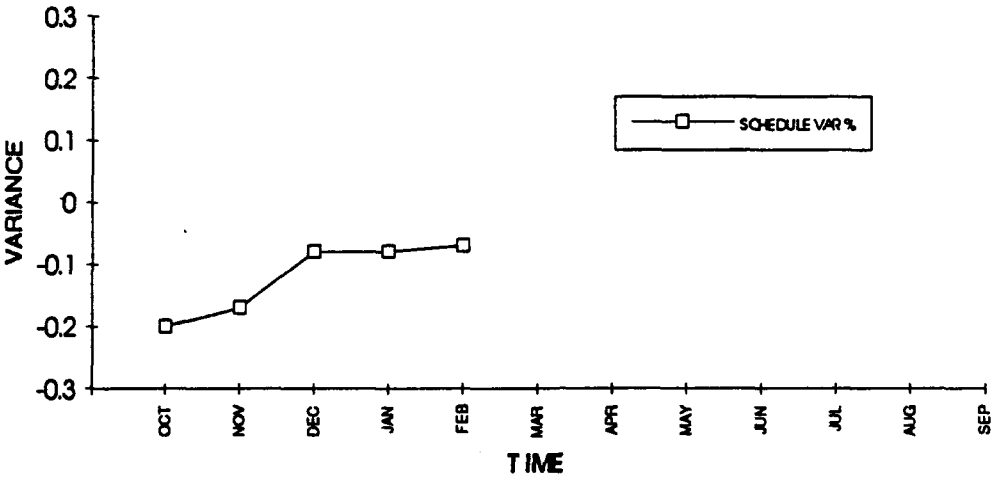
The DMPTR approach consists of two reports, one for schedule and one for cost. CVs and SVs are cumulative. The convention of a negative variance meaning behind schedule or over cost is the same for EV techniques. Figures 3 and 4 data identify work behind schedule and over budget.

To fully explain these two reports, the thesis describes some of the unique terms used in the report. The following discussion of these two reports is based on preliminary HQ AFMC guidance (9). The heading and ending signature portions of the reports contain self explanatory administrative data, but the terms used in the bodies need to be described. The schedule and cost reports contain columns representing the fiscal year months.

Schedule Report. The schedule report provides summary schedule information. The first line in the spreadsheet section of the schedule report is for the Net WAD Quantity (NWQ). The NWQ is the cumulative number of items required by the WAD, spread out on a monthly basis. The next line, "CUM QTY INDUCT" represents the cumulative quantity of items that have been inducted, or started, into the depot repair system. This figure is available in the GOO4L or the G1A reports currently in use. "CUM QTY SCHED" requires a manual calculation and represents the number of items that have been scheduled for

(SAMPLE FORMAT)
DMC SCHEDULE REPORT

ALC: REPORT AS OF DATE:
PRODUCT DIRECTORATE: WAD NUMBER:
WORKLOAD TITLE: PERIOD OF PERFORMANCE:
UNIT SHOP FLOW DAYS:30



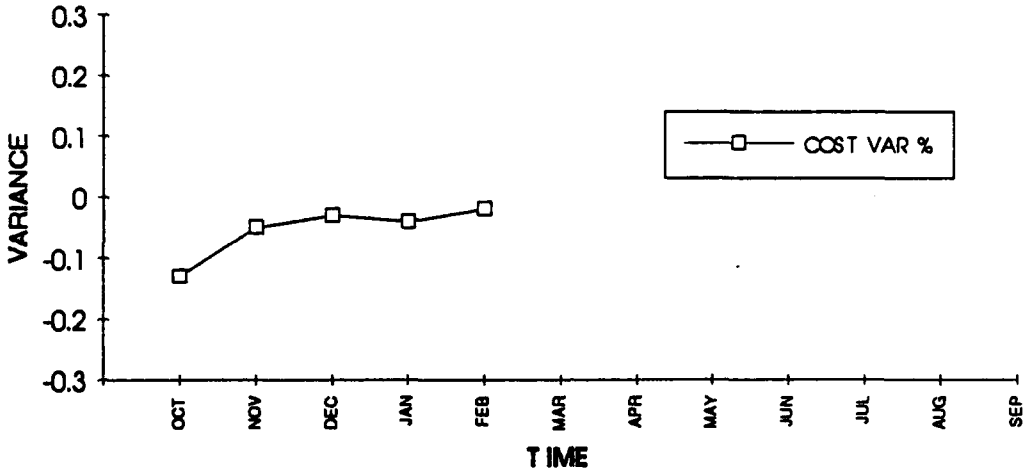
	O	N	D	J	F	M	A	M	J	J	A	S	AT COMPL
NWQ	25	40	70	95	115	140	175	215	245	275	310	350	
CUM QTY INDUCT	0	15	30	65	80	105	130						
CUM QTY SCHED	0	15	30	65	80	105	130						
CUM QTY PROD	0	12	25	60	74	98							
CUM SCHED VAR		-3	-5	-5	-6	-7							N/A
SCHED VAR		-20%	-17%	-8%	-8%	-7%							N/A

TITLE:	SIGNATURE:	DATE:

Figure 3. Defense Maintenance Competition Schedule Report

(SAMPLE FORMAT)
DMC COST REPORT

ALC: REPORT AS OF DATE:
PRODUCT DIRECTORATE: WAD NUMBER:
WORKLOAD TITLE: PERIOD OF PERFORMANCE:



	O	N	D	J	F	M	A	M	J	J	A	S	AT COMPL
NWV	0	4000	7000	9500	11500	14000	17500	21500	24500	27500	31000	35000	
CUM SALES	0	1200	2500	6000	7400	9800							
CUM COST	0	1355	2625	6175	7705	9950							
PROF/(LOSS)	0	-155	-125	-175	-305	-150	0	0	0	0			
COST VAR %	0%	-13%	-5%	-3%	-4%	-2%							

TITLE:	SIGNATURE:	DATE:

Figure 4. Defense Maintenance Competition Cost Report

completion during each month. The CUM QTY SCHED is analogous to BCWS. (9)

The next line, "CUM QTY PROD," cumulative quantity produced, is the number of items actually produced during that month. This quantity is the total BCWP for completed items for the month expressed in terms of item count.

The fifth line, "CUM SCHED VAR," cumulative SV, and represents the difference between the number of items produced and the number of items scheduled.

The sixth and final line on the schedule report is the "SCHED VAR %," which is the cumulative SV percentage. This is obtained by dividing the CUM SCHED VAR by the CUM QTY SCHED, and is graphed directly above the spreadsheet area.

Cost Report. The cost report requires the calculation of quantities analogous to EV quantities. As in the schedule report, the top and bottom of the report are self explanatory, and the spreadsheet quantities require explanation. The first line, NWV, is the Net Work Value that is the actual dollar budget figure for the WAD if completed as planned.

The next line, CUM SALES, is the cumulative sales that represent the amount that will be billed to the customer from the G004B Project Order Control System. The seller bills the customer at the agreed to sales price for items completed.

The third line, CUM COST, is obtained from the G072A Depot Maintenance Production Cost System and represents the cumulative costs through that month on this WAD. CUM COST is directly comparable with ACWP. The fourth line, PROFIT/(LOSS), shows whether the price charged to the customers was above or below the costs incurred. PROFIT/(LOSS) is calculated in the same manner as the EV CV is computed and impacts future pricing rates. The last line, COST VAR %, is the cumulative CV percentage, which is calculated by dividing the Profit/Loss by cumulative sales. This quantity is graphed directly above the spreadsheet portion.

The DMPTR is not a true performance report. It does, however, represent an attempt toward an interim management tool, approaching an EV concept implementation. As noted, the DMPTR does not include the progress on partially completed units, or work in process, and therefore does not equate to EV performance measurement. To obtain more complete information, the ALCs will need to implement a cost and schedule control system that can collect and incorporate data on work in process. The DMMIS system, discussed later, when fully implemented may provide work in process data.

Programmed Depot Maintenance Scheduling System. Although many program specific management tools and computer programs exist to help managers track schedules, the Programmed Depot Maintenance Scheduling System (PDMSS) is one that is widely used within Air Force depots (5:4). The PDMSS has the capability to perform resource loading, resource leveling, and

"what if" analysis when manpower/material requirements and availability are input (5:4).

"The [PDMSS scheduling] network is based on the activities generated by the depot's G037 system. This system generates standard hours for each of the tasks required to maintain the airframe." Precedence relationships are then taken into consideration to develop "the earliest and latest start and finish dates for each task, as well as the critical path (5:4)." Actual and standard hours completed are recorded. These standard hours completed are the BCWP for the job. (5:4)

PDMSS does not provide on going schedule measurements, except for standard hours. The measurement of ongoing schedule status requires a more comprehensive performance measurement system. While PDMSS does represent an available scheduling system, it does not utilize EV relationships and can be considered an interim tool pending application of the EV concept at the ALCs.

F-111 Stores Management System Upgrade Program. The F-111 SMS Upgrade Program represented an attempt to replace system components utilizing current technology and using in-house SM-ALC resources. The Program was established under system acquisition procedures and included both development and production phases, the cost of which was estimated at approximately $100 million. Because the remaining F-111 aircraft in the Air Force inventory were designated for retirement, the program was canceled.

There were numerous organizational and system challenges present in assuming responsibility for this acquisition activity effort. Aside from the technical tasks, the need for management cost and schedule data was evident.

On the F-111 SMS Upgrade program, the primary software tool used in the compilation of EV quantities was a common spreadsheet program. The financial manager collected BCWS, BCWP and ACWP figures from the software development and engineering organizations working on the program. The financial data was then entered into the spreadsheet. (5:1)

The F-111 SMS Upgrade example illustrated that to implement a successful EV approach to cost and schedule performance measurement, one should not only collect data, but also ensure that the data collected is valid. The financial manager collected data as required, but was unable to assure the data's validity. To accomplish more accurate data collection, program personnel must be trained, adequate computer resources must be acquired, and program structure must incorporate work small enough to accurately assign EV.

Depot Maintenance Management Information System

As illustrated by the F-111 SMS Upgrade program, implementing an EV program without the proper software tools can be frustrating and difficult. A system that will aid the implementation of EV on future routine maintenance and acquisition activity programs, is the DMMIS. This system will eventually replace the many legacy systems.

The Air Force concept for DMMIS operation is to provide production information services for depots similar to those production information services provided by Manufacturing Reso-urces Planning (MRP II) systems used commercially. DMMIS uses a common data base to interactively tie six functional areas: general ledger, time and attendance, budget, customer order management, and cost management. (16).

The following DMMIS discussion is divided into two parts. The first part covers DMMIS programmatic issues. Programmatic issues include the schedule status of the DMMIS program, the possibility for DMMIS configuration changes, the possibility of DMMIS deployment across Air Force wide depots or DOD wide depots, and identification of DMMIS program management responsibility. The second part discusses DMMIS technical issues, including currently planned DMMIS capabilities and DMMIS flexibility for possible future capabilities to improve the manageability of depot programs. The technical issues are presented with a perspective on the comparison between DMMIS capability and the EV performance measurement concept.

Programmatic Information. In 1992, the DOD selected DMMIS as the standard cost performance measurement system for military depot maintenance operations for commodities. The Joint Logistics Systems Center (JLSC), WPAFB, Ohio, a DOD organization, assumed management of DMMIS from the Air Force on July 1, 1994.

DMMIS was installed on a test trial basis at OO-ALC, Hill AFB, Utah, in late 1993, to measure cost performance of the C-5A landing gear maintenance program. During the first phase of DMMIS operation on the program, OO-ALC operated the old legacy system in parallel with DMMIS to ensure that the DMMIS results were accurate. DMMIS now operates at OO-ALC at the C-5A landing gear maintenance depot, on a standalone basis.

Technical Information. DMMIS is being developed to meet the unique conditions encountered in depot environments. These include the method for managing floating inventory and providing material management cost data. (16)

DMMIS also supports all CV measurements. Although the current DMMIS configuration provides schedule status information, it does not compare schedule status information with the planned (or budgeted) program schedule. (16)

DMMIS Capabilities. DMMIS capabilities provide flexibility to track anticipated complex weapon system acquisitions and upgrades. A critical key to the ability of EV to accurately measure performance on work in process is the organization of the overall task into cost accounts. The effectiveness of EV as a management tool is accomplished through the establishment of responsible managers for the established cost accounts. DMMIS demonstrates similar characteristics and capability.

Bill of Material. DMMIS organizes work orders by the bill of material (BOM). In routine maintenance activities, DMMIS maintains the parent to child

relationships between parts, subassemblies, and assemblies, to three levels, while fulfilling the floating inventory requirements of efficient depot operations. (16)

Workcenter File. DMMIS retains organizational relationships to seven levels, the lowest of which is the workcenter. The levels of organization from lowest to highest are: workcenter, resource control center (RCC), section, branch, division, directorate, and center. DMMIS manages a maximum of 38 attributes for each workcenter, four of which are currently mandatory: workcenter identification, workcenter description, workcenter type, and RCC link. Other currently used attributes include primary resource, secondary resource, personal fatigue and delay factor (PF&D), capacity, queue time, and move time (16).

Employee Master File. DMMIS maintains personnel information that supports a clear structure of authority and accountability. DMMIS maintains a maximum of 25 employee attributes for each employee in the operation. Ten attributes for each employee are currently mandatory: employee identification, which is linked to the social security number; employee labor rate; employee production acceptance certification (PAC) codes, indicating the employee's qualifications; the work center to which the employee is assigned; the foreman assigned to the employee; assigned skill codes (16).

Cost Accumulation. DMMIS accumulates costs at the workcenter level from four areas, including labor, material, production overhead, and general and

administrative (G&A) overhead. DMMIS cost collection supports actual costs, planned costs for the establishment of standards (budgeted costs), and frozen costs for the establishment of two year stabilized rates. The CV is calculated as the standard cost ,or BCWP, minus the actual cost, or ACWP. CVs at the work center level are rolled up to the project level to indicate overall project performance.

While DMMIS could be modified to combine baseline and current cost information to calculate SV, it currently only provides detailed, real time cost performance measurement. However, it appears DMMIS can be modified to calculate SV information. (16)

The Project Administration Office

While computer support systems are critical to obtaining current cost and schedule information, management control systems must also be in place that can act on this information. The current ALC organizational structures are being evaluated to identify possible changes that may facilitate better management of maintenance and weapon system upgrade programs.

In programs won through a Public/Private competition, concerns were raised about administration oversight. The PAO concept was developed in response to these concerns, and in order to facilitate better management practices. The PAO was envisioned as a high level administrative element

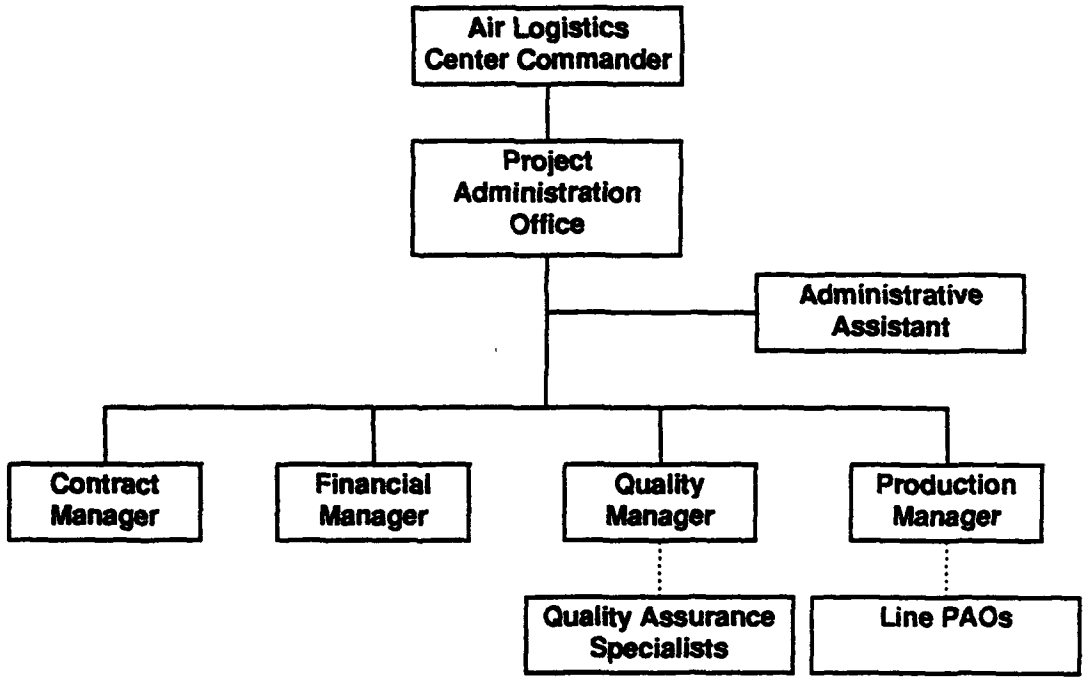


Figure 5. Project Administration Office Organizational Structure

reporting directly to the ALC commander. A sample PAO organizational structure is shown in Figure 5. (28)

Summary

Many changes are taking place in the organic maintenance environment. ALCs are faced with changing workloads. These involve acquisition activities and inter-service department competitions for major system acquisition and routine maintenance programs. In order to aid programs fulfilling new data requirements, HQ AFMC and the JLSC are promoting advanced computer systems, such as DMMIS.

Finally, the reports and data generated can help ALC program management if used in the management control of programs. Of course, the data must also be timely and valid. Because of this, new organizational structures will be needed to help ensure program status measurement is valid.

V. Conclusions

Overview

This thesis focused on the application of the EV concept at Air Force ALCs, and identified trends in organic maintenance management. For the first time, cost and schedule performance measurement similar to EV is being considered for application on Air Force organic maintenance programs.

In this era of DOD drawdowns, the Services are seeking to become even more competitive. Applying EV to organic maintenance programs can improve the competitiveness of the implementing depots.

The discussion of this dynamic management opportunity is organized into three areas. The first reiterates the Research Questions and provides answers to them. The second area discusses findings resulting from the data collection. The third and final area details opportunities for future research.

Research Questions

The thesis sought to answer four research questions. These questions were answered through a combination of a general literature review, compilation of Air Force guidance, and personal interviews. The thesis investigations are listed below.

The existing procedures, processes, and systems used to acquire cost and schedule performance data within organic maintenance. The current

requirement for cost and schedule performance data is envisioned as the DMPTR. This report can be created on a monthly basis, and can be applied on programs competed with industry. This report can be prepared on a spreadsheet program, using data from the existing Air Force legacy computer systems.

Numerous computer-based systems are involved in cost tracking. The existing web of systems used by Air Force organic maintenance organizations is complicated and provides insufficient data for EV measurement. DMMIS can replace many of the existing systems and could support EV measurement.

The cost and schedule performance measurements used for organic maintenance by the Air Force at higher management levels. The current measurements in use by the ALCs are obtained from the several legacy systems. These measurements include CVs and SVs along with cost and schedule percent variances. Many of these quantities are related to EV quantities, or can be converted. As the DMMIS system is implemented at all depots, the cost and schedule reporting requirements can be fulfilled by automated DMMIS reports. Organic maintenance management would then have a more effective management tool. DMMIS, with some changes, could compute all EV quantities.

When existing performance measurements were provided to management and if these measurements were effective for managing programs within the organic maintenance environment. Because the cost data elements are

collected by different systems, at different times, in various formats, and are not a part of a common management system, organic maintenance management cannot use the data for cost control. Additionally, there is no formal management system capable of accurately determining schedule progress.

In contrast, new cost and schedule measurements as identified in reports such as the DMPTR should provide a good basis for the analysis of cost and schedule performance. The DMPTR is not a true performance report because some cost information is not current and credit is not given for partially completed units. The Findings section of this chapter details these and other implementation issues.

Whether EV concepts could be implemented by organic maintenance organizations and how could its implementation aid effective program execution. EV measurement allows management control and should be implemented on specified organic maintenance programs. The implementation of DMMIS could simplify EV measurement of organic maintenance.

EV has proven to be a useful management tool on DOD acquisition programs. This is especially true in the management of high cost, multi-year, complex programs. Air Force organic maintenance organizations, which are increasingly performing complex weapon system acquisitions and upgrades, will benefit substantially by using the EV techniques in their management approach.

Findings

This section details seven findings that relate to the implementation of EV to organic maintenance management. A discussion of the factors impacting implementation follows.

A Competitive Edge. Improving cost and schedule performance measurement provides a competitive edge that ALCs should implement and maintain. Along with having modern, cost efficient facilities, the improved performance measurement ability enhances the ALCs' capabilities to attract organic maintenance work.

Organizational Structure. As cost and schedule performance data are collected, one must be sure that the data is valid and accurate. In order to assure that these data are useful, Air Force management is reviewing organizational structures necessary to execute program direction. The PAO initiative is one example of potential organizational structure changes. Other changes may result from the ongoing examination of depot organizational structures due to changing workloads. The examination is focusing on organizational changes that facilitate the timely collecting, reporting, and analyzing of performance measurement data.

Training. There may be a need to provide tailored EV training to Air Force personnel in the organic maintenance environment. Because DODI 5000.2 requires C/SCSC on high cost RDT&E and procurement contracts, the

program offices and supporting staff are familiar with the EV concept. Because the ALCs do not apply C/SCSC, an understanding of the EV concepts may be low.

If the depots are to actively use EV measurement as a tool, the organic maintenance community must be trained. Various organizations, such as the Air Force Institute of Technology, have existing courses to teach EV concepts and could provide this training.

DMMIS Implementation. DMMIS is a powerful tool for the collection of timely cost data. However, the system does not automatically compute SV and percent SV. The system could easily be modified to compare BCWP with BCWS to obtain SVs (16). The JLSC hopes to implement DMMIS at all DOD depots.

EV Data Collection. Many of the cost data collection systems operate with a time lag, which does not allow current costs to be known. This lag impedes the ability of a manager to use cost data for the control of resources, because timely changes that improve cost and schedule performance cannot be made. EV implementation without timely data may be a wasted exercise.

EV Guidelines. Contractors provide cost and schedule information in accordance with C/SCSC. Because concepts such as baseline control and overhead measurement must be defined in an organic maintenance context, implementation guidelines or criteria should be made available to organic maintenance organizations. EV performance measurement systems would be developed and approved in accordance with these guidelines.

Scope of Depot Work. Under the concept of Integrated Weapon Systems Management (IWSM), some of the duplication of responsibility for weapon systems ended. Each major system has a single program manager with overall program responsibility. For example, while the F-16 A and B models were managed at Hill AFB, UT, the more current C and D models were managed at Wright-Patterson AFB, OH. Now, there is a single program manager for the entire F-16 program who resides at Wright-Patterson AFB, OH. In other cases, such as the F-15 program, the program manager resides at the ALC.

In the past, when an ALC-managed weapon system required major modifications and updates, the acquisition centers were usually called on to contract out the work. However, an ALC program manager may choose to have the major modification done in-house.

The modification work performed by ALCs has become increasing complex and costly. These are the types of programs that benefit most fully from the implementation of EV. The best opportunity for cost and schedule performance improvement is the application of EV to these large, multi-year efforts, although smaller and more simple programs should benefit as well.

Areas For Future Research

This thesis has dealt with many different issues and topics related to EV and organic maintenance operations. Five areas of interest warrant future

study, but were outside the scope of this thesis. A discussion of these areas follows.

Management's Use of EV Data. The most important suggestion for future research focuses on how management will use EV data once the EV performance measurement system has been implemented. Additional research could document how EV data is used by management to improve cost and schedule performance.

Case Studies. The researchers were unable to conduct in depth case studies of actual programs trying to implement EV. An example of Air Force EV implementation to an organic maintenance program was the F-111 Storage Management Systems (SMS) Upgrade program. This example identified some difficulties that may be encountered when implementing EV in the organic maintenance environment. A follow-up study of this or another program would add credibility to the conclusions and findings of this thesis.

EV Implementation. Guidelines explaining the implementation of EV performance measurement in the organic maintenance environment has not been developed. Additional research is required to determine what guidelines would benefit the organic maintenance organizations in implementing the EV concepts.

Current Systems and EV. While this thesis described some of the major existing computer systems involved in cost data collection, a more thorough

analysis of these systems would determine whether these systems could be modified to support EV measurement.

DMMIS Supporting EV. DMMIS, once implemented, will facilitate EV measurement. However, the program is not currently being managed with the implementation of EV as a requirement. Additional research could determine exactly how much effort is required to modify DMMIS to automatically calculate all EV quantities as defined by C/SCSC.

Summary

The declining DOD budget and the changing role of organic maintenance present new challenges to Air Force leadership. One promising approach to meet these challenges is the implementation of improved cost and schedule performance measurement, based upon the EV concept, on organic maintenance programs. The Air Force, as well as other Services, has saved money and gained management control by applying the EV performance measurement concept to acquisition programs. Similar benefits can be expected by applying the EV concept to DOD organic maintenance programs.

Appendix A: Definition of Earned Value Terms

These definitions are directly extracted from DOD Instruction 5000.2, pp 11-B-2-1 - 11-B-2-3:

1. Budgeted Cost for Work Scheduled (BCWS) is "The sum of budgets for all work packages, planning packages, etc., scheduled to be accomplished (including in-process work packages), plus the amount of level-of-effort and apportioned effort scheduled to be accomplished within a given time period."

2. Actual Cost of Work Performed (ACWP) is "The cost incurred and recorded in accomplishing the work performed within a given time period."

3. Budgeted Cost for Work Performed (BCWP) is "The sum of the budgets for completed work packages and completed portions of open work packages, plus the applicable portion of the budgets for level of effort and apportioned effort."

4. The Performance Measurement Baseline (PMB) is "The time phased budget plan against which contract performance is measured. It is formed by the budgets assigned to scheduled cost accounts and the applicable indirect budgets. For future effort, not planned to the cost account level, the performance measurement baseline also includes budgets assigned to higher level contract work breakdown structure elements and undistributed budgets. It equals the total allocated budget less management reserve."

5. Management Reserve or Management Reserve Budget is "An amount of the total allocated budget withheld for management control purposes, rather than designated for the accomplishment of a specific task or set of tasks. It is not a part of the performance measurement baseline."

6. Total Allocated Budget is "The sum of all budgets allocated to the contract. Total allocated budget consists of the performance measurement baseline and all management reserve. The total allocated budget will reconcile directly to the contract budget base. Any differences will be documented as to quantity and cause."

7. Contract Budget Base is "The negotiated contract cost plus the estimated cost of authorized unpriced work."

8. Budget At Completion (BAC) is "The sum of all budgets allocated to the contract. It consists of the performance measurement baseline."

9. Estimate At Completion (EAC) is "Actual direct costs, plus indirect costs allocable to the contract, plus estimate of costs (direct and indirect) for authorized work remaining."

Appendix B: Earned Value Measurement Techniques

The 50/50 Technique. This approach allows the contractor to claim 50 percent of the BCWP when the work package is open, and the other 50 percent when the work package is complete. Some contractors modify this approach by using ratios such as 60/40 or 25/75 (7:122). The rationale behind the original 50/50 approach is that on average, all open work packages are roughly 50 percent complete, making the result of this approach accurate. This is also one of the most objective estimation techniques, since BCWP is determined by whether a work package is unopened, opened, or completed.

The 0/100 Technique. This approach is similar to the 50/50 technique in the calculation of BCWP. In this case, a work package gets all of the BWCP when it is complete. This method would tend to show the contractor behind schedule, and is best for work packages that are completed within one accounting month. (7:122)

Milestone Method. This method works best for work packages which last more than a few months. Objective milestones are established throughout the performance period, and the contractor receives a certain percentage of the total BWCP when those milestones are met (7:122).

Percent Complete. This approach requires a monthly estimate of open work package progress. This estimate may be objective or subjective. Objective percent complete is determined by some set of firm guidelines. As an example, one may claim credit for half the construction of a 50 foot fence when 25 feet are complete. In government contracting, where there are often very complicated tasks performed, the development of objective measurements is often not practical. Therefore, DOD contractors will often use a subjective estimate of percent complete.

While the subjective percent complete technique is the least objective technique, it has become widely used in industry. The hope of the customer is that the contractor will be objective in his estimates and have professional integrity. However, due to the possible inaccuracy of this approach, it is best applied to work packages that are short in length. (7:123)

Equivalent and/or Completed Units. This and the next approach, Earned Standards, are best applied to manufacturing efforts. This first method gives a value on each unit, or fractional unit produced. For example, if a contractor builds ten tables that are half done, five equivalent units of table may be claimed and half of the BWCP will be earned. (7:123)

Earned Standards. This technique requires "the prior establishment of standards for the performance of all the tasks to be required" (7:124). Standards derived from historical cost data, and time and motion studies, must be available to implement this measurement method. Earned standards measurement is most appropriate for repetitive manufacturing situations (7:124).

Appendix C: Sample Work Assignment Document (WAD)

WORK AUTHORIZATION DOCUMENT

Program Store Management System				Org. TISAD
WBS # Ref. Scope & Description	WBS Title SMS (Reference Scope and Description)			
WBE# Ref. Scope & Description	WBEM Mary Rivas			
Contractual References SOW #s Fund Cites	FY-Qtr FY94-1	Original	Revision 1	Revision 2
	Date Opened	01 OCT 1993		
	Date Closed	31 DEC 1993		
	Labor Hours	8,414		
	Labor Rate			
	Labor Cost			
	Other Direct Costs	2,000		
	Total Cost	456,073		

Scope and Description of Work

- This WAD includes the following WBS elements:

1.1.1.2.1.3 SMP OFP Detailed Design
1.1.1.2.2.3 DD OFP Detailed Design
1.1.5.1.2.1 Reviews and Audits
1.1.12.1 S/W Engineering Environment

(see attached sheet)

Deliverables and Dates

SMP/DD SRS (Rev) - 15 Oct 1993
SMP/DD IRS (Rev) - 15 Oct 1993
CMP (Rev) - 22 Oct 1993
SMP/DD Draft SDD - 06 Nov 1993 (Interim date 03 Dec 1993)
SMP/DD Draft IDD - 06 Nov 1993 (Interim date 03 Dec 1993)
STP (Rev) - 27 Oct 1993

Comments

Signatures	Project Control/Date	Project Manager/Date	WBEM/Date	Resource Manager/Date
Original	10-13-93	10-13-93	13 Oct 93	13 Oct 93
Revision 1				
Revision 2				

WAD - Work Authorization Document WBS - Work Breakdown Structure WBE - Work Budget Element
WBEM - Work Budget Element Manager SOW - Statement of Work CDRL - Contract Data Requirements List

Scope and Description of Work (Continued)

Software Support is required to define, document and develop the Stores Management Processor (SMP) and Display Driver (DD) Operational Flight Program (OFP). The following tasks will be performed under this work request:

a. Update the SRS, IRS, SDD, STP, CMP, and IDD based on PDR, SSS and SSDD inputs.
b. Perform detail design of SMP and DD OFPs.
c. Continue performing software configuration management on the SEE.
d. Prepare for and participate in software Critical Design Review.
e. Support Software PMR/ILSMT requirements.
f. Generate Software Test Descriptions.
g. Plan schedule for OFP Coding Phase.

Appendix D: Glossary of Acronyms

ACC	Air Combat Command
ACO	Administration Contracting Officer
ACWP	Actual Cost of Work Performed
ADL	Arthur D. Little
AF	Air Force
AFLC	Air Force Logistics Command
AFMC	Air Force Materiel Command
AFSC	Air Force Systems Command
ALC	Air Logistics Center
ASC	Aeronautical Systems Center
BAC	Budget at Completion
BCWP	Budgeted Cost for Work Performed
BCWS	Budgeted Cost for Work Scheduled
BOM	Bill of Material
C/SCSC	Cost/Schedule Control Systems Criteria
CV	Cost variance
CWBS	Contractor Work Breakdown Structure
DAC	Defense Acquisition Commander
DMC	Depot Maintenance Competition
DMMIS	Depot Maintenance Management Information System
DMPTR	Depot Maintenance Performance Tracking Report
DOD	Department of Defense
EAC	Estimate at Completion
ESC	Electronic Systems Center
EV	Earned Value
FAR	Federal Acquisition Regulation
FFP	Firm Fixed Price
FOUO	For Official Use Only
FY	Fiscal Year
G&A	General & Administrative
GAO	General Accounting Office
HQ	Headquarter
IWSM	Integrated Weapon System Management
JLSC	Joint Logistics Systems Center
LOE	Level of Effort
MRP II	Manufacturing Resources Planning
NWQ	Net WAD Quantity
NWV	Net Work Value
OC-ALC	Oklahoma City Air Logistics Center
OO-ALC	Ogden Air Logistics Center
PAC	Production Acceptance Certification
PAO	Project Administration Office, Project Administration Officer

PCO	Procurement Contracting Officer
PDMSS	Programmed Depot Maintenance Scheduling System
PF&D	Personal Fatigue & Delay
PMB	Performance Measurement Baseline
PO	Project Order
RCC	Resource Control Center
RDT&E	Research, Development, Test & Evaluation
SA-ALC	San Antonio Air Logistics Center
SAAD	Sacramento Army Depot
SM-ALC	Sacramento Air Logistics Center
SMS	Stores Management System
SOW	Statement of Work
SV	Schedule Variance
TOAD	Tobyhanna Army Depot
WAD	Work Assignment Document
WPAFB	Wright Patterson Air Force Base
WR-ALC	Warner Robins Air Logistics Center

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Captain John S. Nehr was born on 15 July 1967 in Camden, New Jersey. He lived in Delaware, Virginia, North Dakota, and the United Kingdom, before returning to New Jersey in 1982. He graduated from Collingswood High School in Collingswood, New Jersey in 1985. He then attended Boston University and became a member of the Air Force Reserve Officer Training Corps. In May 1989 he graduated with a Bachelor of Science in Aerospace Engineering and received an Air Force reserve commission. His first tour of duty was at Wright-Patterson AFB, OH as the program manager for F-16 Operational Capabilities Upgrade (OCU) and Air Defense Fighter (ADF) simulator programs at the Training Systems Program Office. He later managed several technology insertion programs within the same program office until being selected to attend the School of Systems and Logistics, Air Force Institute of Technology, in May 1993.

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Vita

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13. ABSTRACT *(Maximum 200 words)*

The growing role of Air Force Air Logistics Centers (ALC) in complex, multi-year developmental programs increases the need for effective cost and schedule performance measurement. In order to effectively manage these activities, timely and accurate cost and schedule information must be collected and compared with an established baseline. The ALCs need a new management technique which facilitates this type of performance measurement. A proven approach to cost and schedule performance measurement in weapon system acquisitions is Earned Value (EV). This approach, required of contractors who are subjected to the Cost/Schedule Control Systems Criteria (C/SCSC), allows the program manager to obtain cost and schedule variances at one month intervals during program execution. These variances will corroborate known program problems, or give a first indication of potential problems within a program. This document describes what performance measurements are currently in use and how the EV concept is being applied to organic maintenance programs. The thesis also relates some of the management challenges which impede the implementation of an EV measurement system at organic maintenance.

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